Annual Dental Radiation Safety Briefing

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Updated 10/04

Purpose

Renew awareness in order to protect

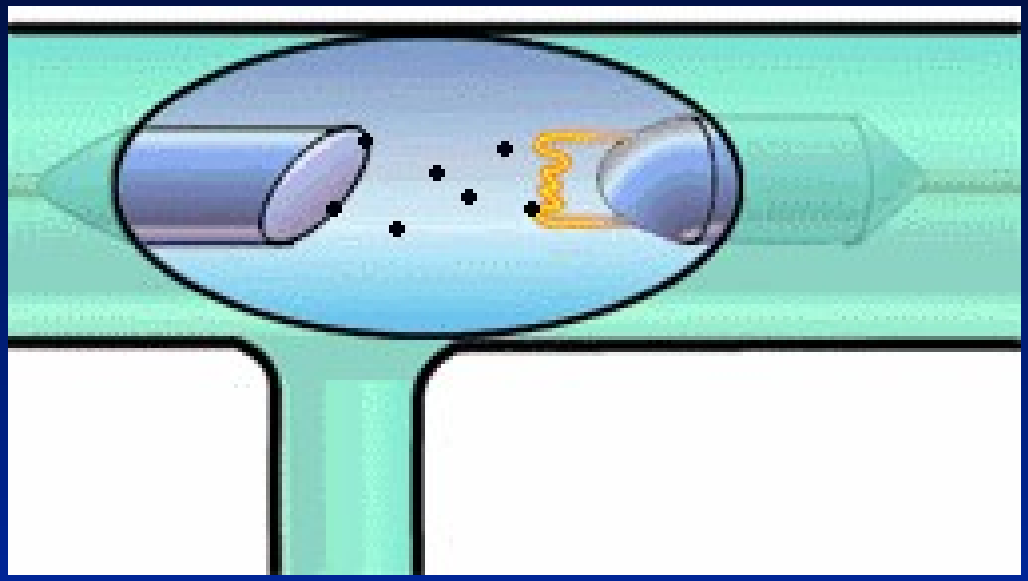
- ✓ **Ourselves**
- ✓ **Our patients**

from any unnecessary hazards

Radiation Tube Head Design

Electrons

Anode



Cathode

X-ray photons

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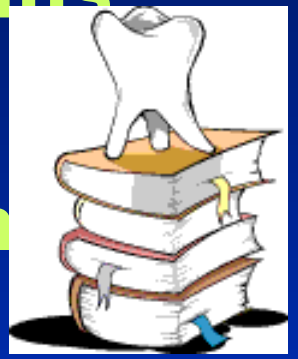
Radiation is Radiation!

Although direct dosage is small, dental radiation can produce biological changes:

- Primary radiation: comes from tube itself
- Secondary radiation: "scatter radiation"
- Background radiation: from "normal" objects around us

How do x-rays affect us?

- Textbook answer--
  - Ionizing form of electromagnetic radiation that alters charges and molecular bonding of structural and regulatory proteins
- Simple answer--
  - Alters tissue function
  - Stops tissue function



OK, but what can they *really* do?

- Biological effects are greatest with rapidly growing tissues
  - Epithelium (cancer)
  - Bone /blood (cancer/leukemia)
  - Gonads (mutations)
  - Thyroid (carcinoma)
  - Fetus (congenital defects)
- Some effects are cumulative
- Cells repair in most situations
  - DNA repair, cell cycle checkpoints

Radiation Units and Measurements

Exposure

- Measures x-ray energy in air
- Exposure Unit (X) *(old unit Roentgen – R)*
- Independent of area or field size

Dose

- Measures x-ray energy deposited in tissues
- Gray (Gy) *(old unit Rad)*
- 1 Gy = 100 Rad

Radiation Units and Measurements

Dose Equivalent

- Allows biologic effect comparison of different forms of ionizing radiation (x-ray vs. gamma)
- Sievert (Sv) *(old unit - Rem)*
- 1 Sv = 100 Rem

For X-rays only

- Dose and dose equivalent the same
- 1 Gy = 1 Sv

Radiation Units and Measurements

Effective Dose Equivalent

- Computes whole organism biologic risk
  - Example: *1 Sv of x-rays to right hand less hazardous than 1 Sv to pelvic bone marrow*
- Adjusts for
  - ✓ Volume of tissue irradiated
  - ✓ Radiosensitivity of tissue irradiated
- Units are Sv (usually stated in mSv)

Assessing Risks from Dental X-rays

- X-rays are potentially dangerous
- Casual attitude ill-advised
- Cumulative risks from x-radiation are assessed as thresholds
- Exposure above thresholds more likely to induce adverse effects
  - Usually requires high dosages
  - Usually requires whole-body exposure

Radiation Skin Effects

- Panoramic local skin dosage 1.74 mSv at molar region
  - Regions will vary in dosage due to tube head speed
- Single film dose 2.0 mSv (localized)
- Increased risk to earliest skin cancer type not evident < 250 mSv dose levels
- **Very small chance** of cancer due to dental radiographs

Radiation Bone Marrow Effects

- Risk to marrow is induction of leukemia
- < 1% body's total marrow exposed to dental x-rays (mandibular marrow spaces)
- Total Mean Active Bone Marrow Dosage
  - 0.142 mSv for FMXR
  - 0.01 mSv for Pano
- ***Threshold leukemia induction estimated <u>whole-body</u> exposure of 50 mSv***

Eye Lens Radiation Effect

- > 2000 mSv required for cataract induction
- FMXR lens dosage 0.4 mSv
- Panoramic lens dosage 0.09 mSv

Radiation Effects to Thyroid

- **100 mSv** reported for thyroid carcinoma induction
- FMXR thyroid exposure **< 0.3 mSv**
- Panoramic thyroid dose **0.04 mSv**
- Effects may be more significant in children because of more active metabolic rates
- **50% reduction** in exposure by using **thyroid collar** on apron

Radiation Effects to Gonads

- Gonadal dental x-ray exposure result of secondary (scatter) radiation
- Gonadal scatter exposure from FMXR is approximately **0.002 mSv**
- **DOSE IS REDUCED 98% BY LEADED APRON!!**
- FMXR gonadal exposure with leaded apron is **10 times less** than average background daily exposure!

Embryo/Fetus Radiation Effects

- Pregnant patients should have radiographs taken if needed for diagnosis
- Congenital defects negligible from gonadal exposures < 200 mSv *(Hiroshima survivor study)*
  - Single x-ray exposure < 0.001 mSv with leaded apron
- Probability of 1st generation defect from dental x-rays is 9 in one billion

Dose Equivalents for Dental Films

- Full-mouth series
  - D Speed Film .084 mSv
  - F Speed Film <.033 mSv
- BWXR (4 films)
  - D Speed Film .017 mSv
  - F Speed Film <.007 mSv
- Panoramic radiograph .007 mSv
- Average natural background radiation 3 mSv / yr (.01 mSv / day)

Compared to Other X-ray Exams . . .

- Chest x-ray 0.01 – 0.05 mSv
- Skull x-ray 0.1 – 0.2 mSv
- Abdomen x-ray 0.6 – 1.7 mSv
- Barium exam 3 – 8 mSv
- Head CT 2 – 4 mSv
- Body CT 5 – 15 mSv

Dental radiographs have a high-perceived but low-actual risk!

Personal risk from dental radiographs is less than driving to appointment

- **FMXR with F film equivalent to < 3 days of background radiation exposure**
- **Dental digital imaging allows shorter exposure times, less patient dosage**

Estimates of Life Expectancy Loss

Health Risk	Time Lost
Smoking 20 cigs/day	6 years
Overweight (15%)	2 years
Alcohol (US Average)	1 year
All accidents	207 days
All natural hazards	7 days
Rad dose of 3 mSv/yr	15 days

Cohen, Health Physics, 1991

Fun fact to know and tell!

Each hour human cells undergo 10 times more spontaneous or “natural” DNA damaging events than would result from the dose absorbed from one panoramic exposure!

Are there limits?

YES! Maximum Permissible Dose (MPD)

- **Amount of radiation received chronically or acutely over a lifetime which (in light of present knowledge) is not *expected* to cause appreciable body injury**
- **Occupational dose is 10 times higher**
  - **Occupational personnel are assumed to accept higher risk of radiation for the lifestyle attained by employment**

Maximum Permissive Dose

- A statistical estimate
  - If all radiation workers received this dose, it is not expected to affect mutation rate of the whole population for any pathological entity
- Does not include radiation that may be received from other non-work sources:
  - Background radiation
  - *Radiation received as part of an individual's medical/dental treatment*

Maximum Permissive Dose

- Lower Maximum Permissive Dose for occupationally exposed pregnant females
  - Same MPD as the general public
- Protects the fetus, who is not considered occupationally exposed

Maximum Permissive Dose

Occupationally exposed

- Whole-body effective dose limit of 20 mSv / yr (new 1998 standard)

General public

- 1 mSv / yr

Pregnant women

- Whole-body effective dose limit of 5 mSv / 9 months

Radiation Protection

ALARA Principle

- As Low As Reasonably Achievable
  - Means every reasonable measure taken to assure everyone receives smallest amount of radiation possible
  - Considered the most appropriate, relevant, and current radiation protection concept

Radiation Protection

Selection of radiographs

- Expose NO ONE to x-rays without good reason
  - Consider patient's current radiographs, clinical findings and history
  - Consider appropriate radiograph(s) required for each individual patient and clinical situation

Radiation Protection

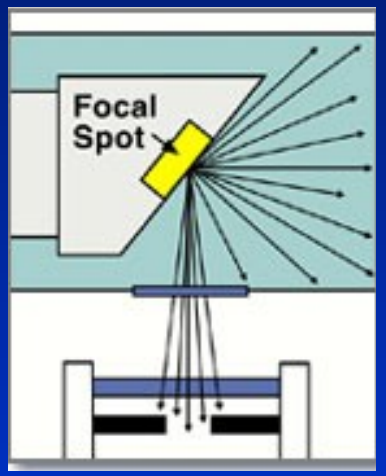
X-ray machine

- Kilovoltage (kVp)
  - Operate at highest kVp consistent with good image and situation (usually 70-90 kVp)
  - Higher kVp produce less low-energy rays
    - Low-energy rays absorbed by patient, do not contribute to image

Radiation Protection

X-ray machine

- Filtration (aluminum)
  - Integral part of tube head
  - Removes low-energy x-rays
  - Should have at least 2.5mm Al equiv (by law)



Radiation Protection

X-ray machine

- X-ray beam collimation
  - Cross-sectional restriction of beam
  - Accomplished by lead diaphragm
  - Federal law mandates 7 cm collimation
    - Same as circular cone

Radiation Protection

X-ray machine

- Use of long cone
  - Long cone causes less beam divergence
- Use of electronic timers
  - Timer should have “Dead Man” control
    - Exposure depends on constant pressure on timer switch

Radiation Protection

At the chair

- F speed film
  - Use fastest & most appropriate film
  - Requires ~2/3 exposure of D speed
- Rare earth intensifying screens
  - Reduce panoramic and extraoral patient exposure
  - Will fluoresce during exposure, provides additional light radiation to film

Radiation Protection

At the chair

- Film-holding devices
  - Reduces patient's dose to fingers
  - Accurately aligns radiograph
  - Avoids retakes due to improper alignment

Radiation Protection

At the chair

- Leaded protective patient aprons
  - Reduces panoramic genetic exposure 98%
  - Reduces thyroid exposure 50% if using thyroid collar
  - Should not be folded!
  - Should be visually inspected for defects
  - Annual x-ray inspection of aprons not required

Radiation Protection

In the darkroom

- Darkroom lighting
  - No light leaks
  - Kodak GBX-2 (red) safelight filter
    - 15-watt bulb (less for F speed film!)
    - Minimum of 4 feet from working area

Radiation Protection

In the darkroom

- Processing solutions
  - Maintained / replenished daily
    - Prevents retakes due to faulty proce

Radiology QA Program

- Written quality control program
  - Monitors all radiology aspects
  - Identifies & remedies problems
  - Reduces retakes
    - Aim for retake percentage < 5%

Staff Radiation Protection

X-radiation sources

- Primary beam
- Scattered radiation
  - Usually from patient skull
- Leakage radiation
  - Through the x-ray machine metal housing

Staff Radiation Protection

Remember:

- X-rays travel in a straight line from source
- X-radiation beam intensity decreases as the distance increases
- X-rays can be scattered in travel path

Staff Radiation Protection

Three considerations:

1) Position – out of primary beam
2) Distance – minimum 6 feet away
3) Shielding – barriers, aprons, walls

Staff Radiation Protection

Position and distance

- Radiology room must have adequately shielded walls
- Do NOT hold films in patient's mouth
- Do NOT stabilize cone or tube head during exposure
- Do NOT restrain patient
  - Provide leaded apron for guardian

Staff Radiation Protection

Shielding

- Operator can be protected by shielding barrier / wall
- Shielding should be of sufficien density & thickness to prevent radiation penetration
- Shielding needs are determined by Bioenvironmental Engineering

Pocket Dosimetry

- Source reference AFI 48-125
  - Base Radiation Safety Officer (BRSO) assesses local clinic radiology department practices and determines local need for dosimetry
  - Dosimetry not required for staff who routinely operate radiographic equipment
  - Pregnant female radiology staff are required to wear dosimetry devices
  - Recommend all BRSO assessments be written communications

Radiation Risks Summary

- Dental radiology risks are small, but cannot be ignored
- Dental personnel need to be knowledgeable about radiation risks to answer patient concerns and protect themselves
- Radiation risks can be minimized by close attention to radiation safety and practicing good radiological techniques

Lecture Bibliography

- Goaz PW, White SC. Oral Radiology Principles and Interpretation, 3rd ed. St Louis: Mosby, 1994
- Langland OE, Langlais RP. Principles of Dental Imaging. Baltimore: Williams & Wilkins, 1997
- Abramovitch K, Thomas LP. X-Radiation: Potential Risks and Dose-Reduction Mechanisms. *Compendium* 14 (No.5):642-7, 1993

Questions

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